Two plates are devoted to a series of detailed sections of the fragmentary materials as distributed around the volcano, and the conditions that influenced the distribution of such materials are discussed.

The essential ejecta are shown to be represented by two strata of brown and black scoria that form the base of the great sheet of lapilli which covered the north-east sector of the volcano, and were so destructive to Ottajano, S. Giuseppe, and other towns. These were followed by the still more important and larger volume of the accessory ejecta derived from the fragmentation and ejection of the upper part of the great cone. One-third of that great cone has gone, as can be seen by the photographs in some of the plates, and a tremendous crater half a mile in diameter and of unknown depth afforded these materials.

The remarkable photographs of the great cone showing this truncation, compared with its original outline and that of the new crater at different dates, make impressive pictures. Plate V. of the memoir, here reproduced in Fig. 2, will remain as a classical view of the general shape of the cone with its scored sides, and Plate VI. of the details of those remarkable barrancos that are like the pleats in a half-opened umbrella. This scoring of the slopes of volcanoes was formerly supposed to be due to aqueous erosion, but is shown in this eruption to be caused by the slipping down of avalanches of loose fragmentary materials piled on the steep slopes of the cone towards the end of the eruption, when the ballistic energy was unable to throw them farther afield.

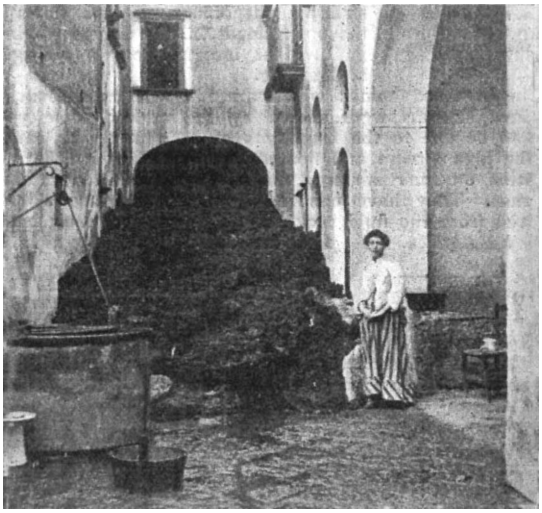

Fig. 3.—Lava that invaded the court of the villa of M. and T. Borosio at Boscotrecase.

Some remarkable "hollow dykes," first described in the 1885 eruption, are given on p. 185, and the mechanism of their formation explained. The author believes they were possibly the canals by which issued the lavas of the Colle Margherita and the Colle Umberto.

The microscopic and other characters of the essential ejecta are illustrated by some plates of photomicrographs. The size of the vesicles, the relative amount of glass, microliths, and state of the magnetite are shown to indicate the position of the magma in the volcanic conduit, the amount of volatile constituents it acquired or lost at different depths, and their relationship to the different phases of the eruption.

The minerals and other eruptive products of the eruption are described in so far as they bear on the interpretation of the eruptive phenomena, but the author avoids petrographical and mineralogical details that he considers have no special bearing on the study of this outburst.

In addition to a large number of reproductions from photographs taken by the author, there are plans, figures, and maps. The last plate is a plan, on the scale of 1/10,000, of the modifications wrought in the cone and crater, printed specially for this memoir by the Istituto Geografico Militare of Italy.

TANTALUM AND ITS INDUSTRIAL APPLICATIONS.[1]

When the announcement was made in the year 1878 that "the division of the electric light had been successfully accomplished," many people believed that the days of lighting by gas had come to an end, and acted accordingly, much to their own disadvantage, for the competition of the glow-lamp served only to stimulate its rival to new life. Burners of improved construction, regenerative burners, and finally gas mantles, helped to restore to gas the ground it had lost, and until a short time ago even threatened to check the spreading of electric lighting.

Not only this growing competition of gas, but the universal necessity of cheapening the production of commodities that are for general use, forced electrical engineers to study in all its aspects the question of improving the efficiency of electric lighting. As a guide in their researches they had the well-known principle that the illuminating power of a solid body increases at a much greater ratio than its temperature, or, in other words, that with the increase of temperature a greater percentage of the energy expended for heating the body is converted into light. There is plenty of room for improvement, for even the most economical source of light, the electric arc lamp, converts only about 1 per cent. of the energy of the electric current flowing through it into light, the rest appearing as heat, so that in reality all methods of lighting devised by men are to a much greater extent methods of heating.

The first successful incandescent lamp consisted of a carbon filament, and for a long time carbon appeared to be the only suitable substance, although the temperature to which such a filament can be raised is limited to about 1600° C., as above this point the carbon begins to disintegrate rapidly. At this temperature the lamp consumes from three to three and a half watts per candle-power, while any attempt to produce light more economically by raising the temperature of the filament results only in shortening its life and destroying, thereby, its power of competing with gas lighting.

An improvement on this result was introduced by Prof. Nernst, of Göttingen, who suggested as the source of light refractory earths, similar in character to those used for gas mantles, which, however, conduct electricity only when they are hot. Lamps constructed on Prof. Nernst's principle have, therefore, to be fitted with contrivances for heating their filaments when starting, which complicate the construction of the lamp.

Another step forward was made by the invention of the osmium lamp, which is produced in a somewhat similar manner to the carbon lamp, by squirting a plastic mixture of metallic oxide and a reducing agent into the shape of a filament, which is gradually heated in a glass bulb by the passage of an electric current, while the bulb is being exhausted by an air-pump or an equivalent device. So far as utilisation of energy goes, these lamps are a great improvement on carbon lamps, but their filaments are very brittle, and the total production of osmium per year is only about 8 kg. for the whole world, of which 5 kg. are required for medical purposes.

In January, 1905, Dr. W. von Bolton, the head of the chemical laboratory of the firm of Siemens and Halske, announced in a lecture to the Elektrotechnische Verein of Berlin that he had succeeded in producing pure tantalum, and his discourse was followed by Dr. O. Feuerlein describing how tantalum had been utilised for filaments in the lamp works of the firm. These discourses presented the result of long years of research work based on the general principle already alluded to, that that filament would give the best economical results which could be maintained for the longest time at the highest temperature.

The number of substances capable of conducting electricity and of sustaining such high temperatures is very limited, and platinum, the most refractory of the well-known metals, had been tried and found wanting. It became, therefore, necessary to start the research by devising methods for producing the rare metals in a commercially possible manner, and then to try one after the other as filaments of incandescent lamps.

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[1] Discourse delivered at the Royal Institution on Friday, April 23, by Alex. Siemens.

While working on these lines Dr. von Bolton succeeded, in the first instance, in producing a vanadium filament by heating a mixture of vanadium pentoxide and paraffin to 1700° C., and thereby producing sticks of vanadium trioxide, which in their turn were heated by electric currents in a glass bulb exhausted by an air-pump, and so converted into metallic filaments. As it was found that vanadium melts at about 1680° C., such filaments were no improvement on carbon filaments, and the next substance to be investigated was niobium, which belongs to the same group of elements, but has nearly double the atomic weight. Treated in a similar manner, the niobium filament gave somewhat better results, but still its melting point, estimated at 1950° C., was too low for practical purposes.

In this connection it should not be forgotten that at a temperature considerably below their melting points all these metals begin either to soften or to disintegrate, so that their "working" temperature is not identical with their melting temperature.

Turning his attention to tantalum, which has an atomic weight of 181, Dr. von Bolton experimented with the black metallic powder produced by the method of Berzelius and Rose, and found that it could be rolled into a fairly coherent mass in the form of ribbons. Alternative experiments, conducted on the lines by which vanadium and niobium had been obtained, resulted in the production of pure tantalum in the form of a metallic button, which was found to be tough and malleable like steel.

These and other qualities convinced Dr. von Bolton that nobody before him had handled pure tantalum, although Berzelius had first obtained the metal by a chemical process in 1824, and later Moissan succeeded, in 1902, in producing it in his electric furnace. The latter describes tantalum as a hard, brittle metal of the specific gravity of 12·8, and a non-conductor of electricity, but he adds that the substance obtained by him contained about half a per cent. of carbon.

Considering the high atomic weight of tantalum, this admixture of carbon evidently exercises a great influence on the physical qualities of tantalum, and explains the differences between the observations of Dr. von Bolton and those of his predecessors. In nature, ores containing tantalum are found in many places, principally in Scandinavia, North America, South-west Africa, and Western Australia. Columbite from South Dakota contains from 10 per cent. to 40 per cent. of tantalum pentoxide (Ta_2O_5), and a good deal of niobium, combined with iron and manganese in various proportions.

As the separation of tantalum and niobium is somewhat troublesome, it is preferable to utilise the tantalite, which consists almost entirely of iron and manganese combined with tantalum pentoxide. From these ores tantalum is separated in the form of a fluoride in combination with potassium (K_2TaFl_7), and subsequently reduced by metallic potassium to the black powder already mentioned, which, however, still contains some oxide and some hydrogen.

In order further to purify the product, the powder is pressed into the form of small cylinders, which are melted in a vacuum, by an electric current under certain precautions, into small buttons of pure tantalum such as are exhibited.

Since the production of tantalum has been carried out on a commercial scale it has been possible to improve many details of the process, so that the tantalum produced by it at the present time is even purer than that shown in 1905 at the discourse of Dr. von Bolton and Dr. Feuerlein.

Some specimens of this latest tantalum have been submitted to Sir James Dewar, who has very kindly made experiments with reference to its specific heat and to its thermal conductivity. He ascertained the specific heat by plunging small spheres of tantalum, which had been heated to the temperature of boiling water, into water of 14° C., then transferring them to melting carbonic acid (−78° C.), and finally to liquid air (−183° C.), and as an average of several experiments the specific heat was found to be between 100° C. and 14° C.=0·033, 14° C. and −78° C.=0·032, −78° C. and −183° C.=0·028, while Dr. von Bolton in 1905 gave the specific heat as 0·0363. Multiplying these results by the atomic weight (181), it will be seen that Dr. von Bolton's value (6·57) is slightly higher and Sir James Dewar's value (5·97) lower than 6·4, which, according to Dulong and Petit, is the atomic specific heat.

The result of Sir James Dewar's experiments proves tantalum to have about three-quarters the conductivity of iron and about one-eighth the conductivity of copper. At ordinary temperatures, say below 300° C., pure tantalum resists the action of all acids except fluoric acid, of all alkalies, and of moisture, so that it is an ideal material for chemical apparatus which do not require high temperatures, and for any implements which, when made of steel, are liable to rust.

It has already been stated that pure tantalum is tough and malleable, so that it can be hammered out into thin sheets or drawn into fine wire, the diameter of the filament wire being 0·03 mm., or about one eight-hundredth of an inch; all the same, it is elastic and as hard as soft steel, and has a tensile strength of 93 kg. per square mm., which is equal to 57 tons per square inch. This means that the filament wire is capable of supporting about 80 grams, or 2·8 ozs., as can be shown by actual experiment.

Tantalum sheet can be stamped into various shapes, and out of bars of tantalum springs can be bent. Another use made of tantalum is as material for writing pens, manufactured in the usual way. When it was first offered for this purpose it was found that the material could not pass the test prescribed for pens made of steel. These are pressed by a weight of 180 grams on writing paper which is moving at the same speed as ordinary writing, and while 10 km. (6¼ miles) of paper are passing the loss by abrasion must not exceed 0·7 mg. (0·01 grain).

At first the tantalum pens lost more than double the permitted weight, but it was found that slightly oxidising the surface of the pens hardens them so much that they only lose 0·8 mg. by the 10 km. test. By weight this is still more than is permitted for steel pens, but having regard to the specific weights of the two substances the actual volumetric abrasion of the tantalum pen is the lesser of the two.

Although only the surface of the pens had been oxidised, it was found that the rate of abrasion remained the same for the whole length of 10 km., when it was expected that this rate would increase materially after the skin of oxide had been ground off.

Advantage was taken of this circumstance when an inquiry was received from India as to whether it would be possible to manufacture cataract knives for oculists out of tantalum. The qualities demanded of such a knife are that its blade should be (1) intensely hard, so as to be able to acquire a very sharp edge of great smoothness, and to retain this fine edge for a long time; (2) very tough, without any tendency to bend; (3) chemically and mechanically stable, so that it can be easily sterilised and that it is not liable to rust; (4) capable of acquiring a high polish. Manufacturing such a blade out of pure tantalum, and slightly oxidising it before polishing it, appears to fulfil these stringent conditions, but as the knife, which is on the table, has not yet been actually tried for an operation, it can only serve to demonstrate the similarity of tantalum to steel for such purposes.

Another field for the application of tantalum may be found in the supply of dental instruments, owing to its immunity from chemical changes, but beyond showing two cases of such appliances there is no necessity to go further into details. While possessing all these qualities of a true metal, tantalum has some others which rather limit its usefulness. When heated to a dull red heat it absorbs gases greedily, especially hydrogen and nitrogen, and by combining with them it loses its tensile strength and becomes brittle.

Here are three pieces of tantalum wire taken from the same coil; one of them has been heated in an atmosphere of nitrogen, the other in hydrogen, and the third has not been interfered with. The consequence is that the latter has retained its strength, while the former have become brittle and useless. On heating tantalum in air, it shows first a yellow and then a blue tint like steel, but when the heating is continued it burns to pentoxide. The black powder and thin wires can even be lighted by applying a match to them, as the experiment shows.

Its melting point *in vacuo* lies between 2250° C. and 2300° C., which makes it particularly suitable for electrodes in vacuum tubes, especially as it does not disintegrate. For example, it is extensively used in Röntgen tubes. Its specific weight is 16·6.

Turning now to the electrical qualities of tantalum, its specific resistance was stated by Dr. von Bolton in 1905 to be, on the average, 0·165, with a temperature coefficient of 3 per cent. between 0° and 100° Celsius.

Further experiments conducted by Dr. Pirani in the laboratory of Siemens and Halske revealed the fact that wires of various thicknesses varied in their specific resistance from 0·173 to 0·188, but after they had been heated to 1900° C. in a high vacuum for from 100 to 200 hours, they all possessed the same specific resistance, viz. 0·146, and their temperature coefficient between 0° and 100° C. had risen to 0·33 per cent.

As the temperature of a tantalum filament, when consuming 1·5 watt per candle-power, is about 1850° C., and its resistance about six times its resistance at 100° C., the temperature coefficient between 100° C. and 1850° C. may be taken, on the average, as 0·29 per cent.

No doubt the difference between these results is caused by alterations in the structure of the wires during their manufacture, and the heating *in vacuo* served a similar purpose to the annealing of steel, so that Dr. Pirani's results published in 1907 may be taken as standards.

At present the most important industrial application of tantalum is its use for filaments of incandescent lamps, which may be said to date from July, 1903, when Dr. Feuerlein succeeded in producing a tantalum wire one-twentieth of a millimetre in diameter. Of this wire he made a glow lamp with a filament 54 mm. long, using a current of 9 volts 0·58 ampere, and giving a light of 3·5 candles (Hefner), at the rate of 1·5 watts per candle-power.

A simple calculation shows that for a current of 110 volts 660 mm. of the same wire would be required, giving at the same rate of consumption of energy a light of 43 candles.

In carbon lamps, for 220 volts the length of filament is only 400 mm., and the filaments remain hard until they disintegrate. Tantalum filaments, like other metallic filaments, soften, however, to such a degree that they cannot be used in the same shape as carbon filaments.

After trying various methods of housing the long Ta filament in a glass bulb of approximately the same dimensions as the carbon glow lamps, the present form was arrived at during the year 1904. In this lamp, which was adopted as standard, the length of the filament was 650 mm., its diameter 0·05 mm., and its weight 0·022 gram, so that about 45,000 of these lamps contain 1 kg. of Ta.

Since then these dimensions have been modified to a certain extent; for instance, the diameter of the filament is now only 0·03 mm., but the external shape has not been altered.

It was soon found that after burning a short time the filament underwent certain structural changes and lost its great tensile strength. Examination under a microscope revealed the fact that in about 1000 hours the smooth, cylindrical filament shows signs of capillary contraction, as if the cylinder was going to break up into a series of drops, and the surface, from being dull, commences to glitter. This contraction of the filament after being heated is readily recognised by comparing a new lamp with an old one. On the stars of the new lamp the filament hangs loosely, while in the old lamp the filament is evidently in tension.

The characteristic difference between carbon filaments and tantalum filaments is shown by a diagram representing the influence of temperature on the electric resistance of the two filaments in proportion to each other.

In order to have the differences at once shown in per cents., the normal pressure and the normal resistance of both filaments, when giving the light of 1 candle for 1·5 watts, is marked as 100, and it is immediately seen that the resistance of Ta alters directly, and that of carbon inversely, as the temperature. Owing to this quality a Ta filament is better able to resist overheating than a carbon filament, as the following experiment shows, where two lamps, one Ta and one C, burning normally at 110 volts with 1·5 watts per candle-power, are gradually exposed to higher voltages. The C lamp breaks, while the Ta lamp stands up to 200 volts, the highest voltage available here. Of course, its useful life will be shorter than at its normal voltage.

As stated at the beginning of the discourse, the primary object of all the research was to find a filament more economical in the consumption of electrical energy than the C filament, and the following experiments will show that the Ta filament is in this respect a great improvement on the C filament. To begin with, a comparison can be made by burning a Ta and a C lamp under water, each being immersed in a vessel containing the same quantity of water. Owing to the C lamp requiring more energy to give the same light as the Ta lamp, the temperature of the water in the C vessel rises quicker than in the other vessel. Another way of showing the difference is by measuring the current taken by each of the two lamps when giving approximately the same light, or by sending the same current through both lamps in series and noting the difference in candle-power.

In conclusion, two interesting qualities of Ta should be noted. The first is that, when a Ta filament is heated in a high vacuum, it will expel any oxygen that has combined with it. It is possible to detect whether a filament contains any oxide by very gradually heating it up, when the parts containing oxide will appear brighter than those consisting of pure Ta, owing to the greater electrical resistance of the oxide.

These lamps have been purposely exposed to the air while they were being exhausted, and have become "spotty" in consequence, but if they are raised a little above their proper voltage and left burning for a few minutes their filaments become quite uniform by the expulsion of the oxygen.

The second quality is that Ta will act as a rectifier when used in an electrolyte, that is to say, it will allow the passage of the positive current only in one direction. In the apparatus shown the positive current passes through the lamp to a Ta anode, thence to a Pt kathode, but in a very short time the Ta anode covers itself with a film of oxide which stops the current. When the current is reversed the lamp lights again, and continues to burn. When an alternate current is connected to the lamp it will also continue to burn, but with diminished brilliancy.

All these experiments are intended to show the remarkable qualities of this material, and when they are fully appreciated and its limitations are properly understood there appears to be a great field open to tantalum and its industrial applications.

CONFERENCE ON ROADS.

A CONFERENCE arranged by the County Council Association, in conjunction with the Association of Municipal Corporations, the Urban and Rural District Councils' Association, the Association of Municipal and County Engineers, and the County Surveyors' Association was held in London last week, and lasted over three days. The meetings were divided into three sections, which met at the Institution of Civil Engineers, the Mechanical Engineers, and the Surveyors' Institution.

This conference was very largely attended by borough and county engineers, chairmen and members of the Roads and Bridges Committee of county councils, and others interested in automobiles.

Following on the International Road Congress held at Paris last year, this gathering together of those responsible for and interested in the management of the highways of this country shows the increasing importance of road traffic and of the interest taken in the condition of our highways.

Forty papers were contributed for reading and discussion, the subjects dealt with relating to the construction and maintenance of roads; motors and traction engines,